IN-VIVO MONITORING WITH MICROWAVES

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a national phase application of International Application No. PCT/GB2011/052107, filed Oct. 28, 2011, claiming priority to UK Application No. 1018413.3, filed Nov. 1, 2010, both of which are incorporated by reference herein in their entirety.

FIELD

The invention relates to in-vivo monitoring of a blood glucose level using microwaves.

BACKGROUND

The monitoring of a blood glucose level in a living body, typically a human, is a well known diagnostic test. A person may need to monitor their blood glucose level carefully if they suffer from diabetes.

There are many known kinds of blood glucose level monitoring device. A commonplace class of blood glucose level monitoring device is the "blood strip meter". A blood strip meter makes measurements on a very small amount of blood captured on a disposable, strip-like carrier that is docked with the device to perform the analysis. The blood is obtained by wiping the strip over a pin-prick wound.

SUMMARY

The invention is defined by the appended claims, to which reference should now be made. Some features of some embodiments of the invention will now be described.

In certain embodiments, the resonator is designed to feature first and second resonances, with the first resonance experiencing a perturbation by a living body in proximity or contact with the resonator, and the second resonance experiencing no such perturbation. Actually, in a practical embodiment, the second resonance may in fact exhibit such a perturbation, but to a small degree that is negligible relative to the perturbation experienced by the first resonance. The first and second resonance may be, for example, peaks or notches, depending on implementation. The detecting means may be arranged to measure the height of one or both of the resonances; the height could be the height to the crest of a peak or to the bottom of the trough of a notch.

The ring or rings mentioned in the claims are preferably circular but not necessarily so. Where there are several rings, they may differ in shape to one another. The ring or rings may be mounted on a pillar or support made of electrically insulating material.

The detection means typically comprises means for measuring the power versus frequency for microwaves passing through the resonator.

Typically, the frequency of the microwaves that are passed through the resonator is swept or stepped and the power of microwaves that have travelled through the resonator is measured at various frequencies.

Where the resonator comprises two rings, each ring will give rise to a respective peak in the resonant response of the resonator. Measurements made on one peak may be used to provide a reference point for measurements done on the other peak so that systematic errors such as those due to changes in temperature or humidity can be avoided.

At least some embodiments of the invention provide one or more of the following advantages:

- The monitoring is conducted non-invasively. This means that there is no risk of the scarring that can occur with devices such as blood strip meters.
- The monitoring may be conducted continuously. The non-invasive nature of the invention greatly facilitates continuous monitoring. That is to say, a monitor according to the invention may be attached to a subject (e.g. by a belt or adhesive) to assess a blood glucose level periodically over an extended interval (e.g. every 10 minutes over a 72 hour period).
- Relative insensitivity to placement. That is to say, certain monitors embodying the invention need not be mounted to a specific body part and/or the same location on a given body part.
- Relative insensitivity to the pressure with which the monitor is applied to a subject. That is to say, certain monitors embodying the invention produce blood glucose measurements that are unbiased by the degree to which the monitor is pressed against the subject's body.

BRIEF DESCRIPTION OF THE DRAWINGS

By way of example only, certain embodiments of the invention will now be described by reference to the accompanying drawings, in which:

FIG. **1** is a schematic block diagram of a non-invasive blood glucose monitor;

FIG. **2** is a cross section through the sensor shown in FIG. **1**;

FIG. **3** is a spectrum obtained from the sensor of FIG. **1**;

FIG. **4** is another spectrum obtained from the sensor of FIG. **1**; and

FIG. **5** is a further representation of the spectrum of FIG. **3**.

DETAILED DESCRIPTION

FIG. **1** shows a non-invasive blood glucose monitor (NIGBM) **10** according an embodiment of the invention. The NIGBM **10** includes a sensor **12**, a vector network analyser (VNA) **16**, coaxial leads **18** and **20**, a USB lead **22** and a laptop computer **24**.

The sensor **12** is for application to a living body **14** on which blood glucose monitoring is to be performed. The vector network analyser **16** is connected to the sensor **12** via the coaxial leads **18** and **20**. The VNA **16** sends microwaves into the sensor **12** through lead **18** and receives through lead **20** microwaves that have passed through the sensor **12**. The VNA **16** sweeps the frequency of the microwaves that it inputs to the sensor **12** and records in digital form the power versus frequency spectrum of the microwaves that are received from the sensor. The laptop computer **24** retrieves the spectrum from the VNA **16** via the USB lead **22** and makes measurements on it to assess the blood glucose level of the living body **14** (hereinafter referred to as the "subject"). These measurements will be described later with reference to FIG. **5**.

The sensor **12** is a largely a cylinder and FIG. **2** shows the sensor in cross-section through the plane containing the cylinder's axis. The cylinder's axis is substantially perpendicular to the subject when the sensor is applied to the subject. The sensor **12** comprises a brass housing **26** that provides the curved walls and one face of the cylinder. The other face of the cylinder is provided by a window **28** of insulating material that is transparent to microwaves (e.g. a material such as